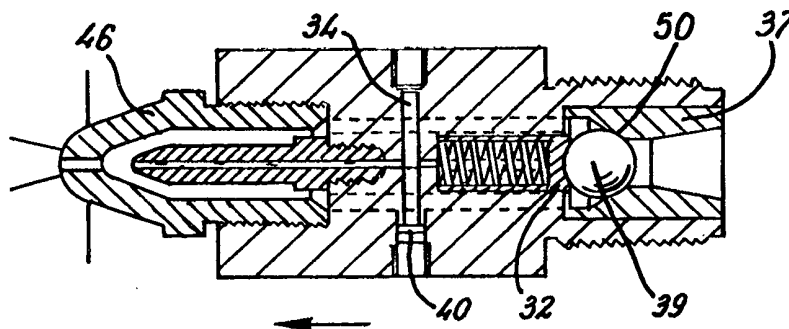




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(54) Title: NOZZLE VALVE FOR GAS ASSISTED INJECTION MOULDING (57) Abstract A nozzle valve nozzle suitable for use with gas assisted moulding apparatus. The nozzle valve has a body (30) which defines a passage (38) for plastic and includes a means for closing off the passage, which means may be a ball valve (39). The valve body (30) also defines a gas injection port (34) for the supply of gas under pressure to plastic supplied through the passage (38), and includes a means for isolating (40) the gas injection port (34) from the passage (38) and a means for activating the means for isolating (40) under the control of gas pressure. The means for isolating the gas injection port can be a spring loaded needle valve (40) arranged to open under gas pressure. A means for assisting the means for closing off the passage (38) can also be provided, in the form of a piston (32) arranged to close the ball valve (39) under the influence of gas pressure supplied via a further gas port (35).		



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NOZZLE VALVE FOR GAS ASSISTED INJECTION MOULDING

The present invention relates to a nozzle valve. The nozzle valve is particularly, but not exclusively intended for use in a gas assisted injection moulding apparatus and process.

5 A means of shutting off or isolating the flow of plastic from an injection screw and cylinder to a passage to the mould is well known and is frequently used in the conventional plastic injection moulding process. The passage connecting the moulding machine screw and cylinder and the mould is normally through a nozzle attached to the machine cylinder.

10 In conventional injection moulding a means of isolating the plastic is achieved with a shut-off valve which is normally located in the machine nozzle or in an additional adaptor assembly mechanism located between the nozzle and the cylinder.

15 The normal reason for use of a shut-off nozzle is to prevent the further transfer of plastic to the mould after the required shot volume has been injected, and/or to prevent plastic dribbling or being forced from the exit aperture of the nozzle after the nozzle has been separated from the nozzle seating in the mould, or after the mould has opened and the moulding ejected.

20 Normally the seating is part of the mould sprue bush or a bush at the entry to a cold or hot runner system.

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This procedure is often necessary when the screw is rotating whilst refilling the cylinder with plastic, after the injection of a shot of plastic into the mould, particularly when the separation of the nozzle and nozzle seating by withdrawing the machine injection cylinder carriage has occurred.

5 Withdrawing the machine injection carriage and nozzle is often referred to as 'sprue break'.

It is normal practice to apply hydraulic pressure or other means to resist the backward movement of the screw as it rotates and refills the cylinder. This pressure, often referred to as 'back pressure', is normally

10 necessary to adequately pack the material prior to injection of the next shot of plastic into the mould. It may also be used to improve the mixing of the plastic with colourants and other additives. In some cases back pressure is used to create additional heat as a result of friction between the plastic and the screw, thereby raising the temperature of the plastic. Back

15 pressure further contributes to the need for shutting off the plastic.

Sometimes screw refill continues after the sprue break and/or mould opening, and therefore it becomes essential to stop material under pressure from being extruded from the nozzle aperture.

In order for these functions to operate, it has become normal practice

20 for nozzle shut-off valves to be designed to resist pressure from the direction of the screw and cylinder.

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In the now well-known and documented process referred to as 'Gas Assisted Injection Moulding' - GAM - a means of shutting off or isolating the plastic in the screw and cylinder from the down stream gas pressure is often required for additional reasons.

5 In the GAM process pressure is applied by the gas during and after its injection into the plastic in order to complete the filling of the mould cavity with plastic and gas, and to pressurise the plastic whilst it is cooling and solidifying in the mould. Therefore, contrary to conventional moulding, pressure is applied from the mould or downstream of the nozzle instead of
10 from the upstream moulding machine screw and cylinder.

 In order to achieve the GAM pressurisation, gas is injected either at selected positions within the mould or from gas injection means within the machine nozzle or adapter assembly between the nozzle and the cylinder head. This procedure therefore creates a pressure from the opposite and
15 different direction compared with conventional moulding. For this reason many of the existing nozzle shut-off valves are not suitable or are not ideal for use with gas assisted moulding.

 In the GAM process it is often necessary to prevent plastic and gas from being forced from the nozzle area back towards and into the screw
20 and cylinder. In these circumstances gas may mix with the plastic, creating a cellular structure and isolated bubbles. In subsequent plastic

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injection into the mould, the mixed gas will create unacceptable visible streaking on the moulded surface and other defects within the moulding. This is most likely to occur if the gas is injected in the nozzle area or when injected in the mould at positions near feed gates, runners or a sprue.

5 It has therefore become established practice to combine means of shutting off the plastic in the screw and cylinder from the nozzle with a means of injecting gas into the plastic in the nozzle.

10 There are already available means of shutting off the plastic, including mechanical devices actuated by hydraulic pistons and cylinders or by high duty springs. In some cases this is achieved by shut-off pistons which move in axial directions or by rotating rods with apertures to open and close passages for the plastic transfer or stoppage. In most cases the methods require enlarging the extension to the cylinder head. In many cases the moving parts which are under load and at high temperatures are prone to
15 excessive wear. They are often expensive to manufacture and operate.

 A disadvantage of the GAM process for some products is the small hole which remains at the entry and exhaust position of the gas in the moulding at the point of gas injection, which may be at in-mould gas injection position or at the sprue or runner feed gate if the gas is injected at
20 the machine nozzle.

 According to one aspect of the present invention there is provided a

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nozzle valve having a body defining a passage for plastic, means for closing off the passage, means for activating the means for closing off under the control of gas pressure, a gas injection port for the supply of gas under pressure to plastic supplied through the passage and means for isolating the gas injection port from the passage.

According to another aspect of the present invention there is provided a method of gas assisted injection moulding including the steps of supplying plastic material to a mould, applying gas pressure to assist in shutting off the supply of plastic material and to permit the pressurisation by gas of plastic supplied to the mould and pressuring the plastic by gas pressure in the mould.

In a preferred embodiment of the invention, the means for closing off the passage comprises a valve advantageously a ball valve having a spherical or part spherical valve member urged onto a conical valve seat to close the valve by resilient means in the form of a spring. The means for activating the means for closing off the passage preferably comprises a piston operable to urge the spherical or part spherical valve member onto the valve seat, to add a force to that exerted by resilient means where such is provided. A gas port is preferably provided through which gas under pressure may be supplied to operate the piston. The valve may be opened in operation by means of plastic under pressure supplied by a screw and

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cylinder arrangement. The passage is preferably defined by a tubular member which also provides the conical valve seat. The valve is preferably disposed upstream, in relation to the intended direction of plastic flow through the passage, at the point at which gas supplied through the gas injection port exits the passage. The means for isolating the gas injection port from the passage may comprise a valve advantageously having a resiliently loaded valve member disposed to be urged from a closed position to an open position in which gas may be supplied through the port to plastic supplied through the passage to the mould. A means for activating the means for isolating is preferably provided and may comprise a second gas port through which gas under pressure may be supplied to urge the valve member, in the form of a piston, to the open position against the resilient loading advantageously provided by a compression spring. Means may also be provided enabling the nozzle to deliver a plug of plastic material at the end of a moulding cycle to close off the opening left by injected gas. These means may involve opening the means for opening the plastic passage again at the end of the cycle to deliver the plug, or an arrangement for displacing plastic already in the nozzle or by providing an additional piston and cylinder device for delivering a plug of material under pressure. The same supply of gas may be used for the means for activating and for pressurising plastic in the mould. Alternatively separate supplies may be used. The invention also

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comprises moulding apparatus comprising a nozzle as defined above.

According to another aspect of the present invention there is provided a nozzle valve having a body defining a passage for plastic, means for closing off the passage, a gas injection port for the supply of gas under pressure to plastic supplied through the passage, means for isolating the gas injection port from the passage and means for activating the means for isolating under the control of gas pressure.

In order that the invention may be more clearly understood embodiments thereof will now be described, by way of example, in which:-

Figure 1 diagrammatically illustrates apparatus for gas assisted injection moulding,

Figure 2 shows a perspective view of a known gas injection nozzle for use with the apparatus of figure 1,

Figure 3 shows an exploded view of a gas injection nozzle according to the invention,

Figure 4 is a view in section of the valve of figure 3 in a first operational position,

Figure 5 is a view in section of the valve of figure 3 in a second operational position,

Figure 6 is a view in section of the valve of figure 3 in a third operational position,

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Figure 7 is a view in section of the valve of figure 3 in a position in which a slug of material is produced at the end of a moulding process.

Figure 8 is a view in section of the valve of figure 3 in an alternative position to that shown in figure 7,

Figure 9 is a view in section of the valve of figure 3 in another alternative position to that shown in figure 7,

Figure 10 diagrammatically shows the sequence of steps in a first moulding.

Figure 11 diagrammatically shows the sequence of steps in a first moulding sequence, and

Figure 12 is a view in section of another embodiment of a gas injection nozzle according to the invention.

This invention provides a method and apparatus for combining the shutting off and opening of the passage of plastic transfer from the screw and cylinder to the machine nozzle, and the injection of gas into the plastic stream within the nozzle body or nozzle tip. Both functions are precisely controlled for timing and pressures exerted by the use of the already available high pressure gas as a means of activating the shut-off of the plastic and opening and closing the flow of gas.

The assembly for fitting between the cylinder head and the nozzle tip

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may be operated without any external moving parts, and it uses the already available high pressure gas for control and activation of the movements of opening and closing plastic and gas apertures.

5 It is a further objective to economise in space and the outside diameter of the body containing the valves to be little more than the normal nozzle valve fitted to the moulding machines.

The method of manufacture of the assembly is to be comparatively inexpensive to manufacture.

10 The basic design of the combined plastic shut-off and gas injection adapter is to be suitable for small and large injection moulding machines, and to be easily fitted and operated with any make of moulding machine.

Referring to figure 1 of the drawings a conventional gas assisted injection moulding apparatus is shown. As already generally discussed in the introduction, this comprises means for feeding plastic to a mould 1 in the form of an injection screw 2 disposed in a cylinder 3. Plastic is fed to the cylinder 3 via an inlet 4. A shut off nozzle 5 connects the cylinder 3 at its outlet to the mould 1. Gas may be injected at positions 6 and 7 within the mould or at position 8 within the nozzle 5 via gas injection means. One such known means is shown in figure 2. The passage 20 for the supply of plastic is disposed coaxially within the nozzle 5. A rotatable rod 21 having an aperture 22 crosses passage 20 transversely. The rod is

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rotatable by means of a worm gear arrangement 23 between a position in which aperture 22 is aligned with passage 20 to permit plastic to flow and a position in which passage 20 is closed off thus preventing plastic flow.

Figure 3 shows an exploded view of a gas injection nozzle according to the invention. The nozzle comprises a nozzle body 30 which defines a piston chamber 31 in which a piston 32 loaded by a spring 33 is disposed. The nozzle body 30 also defines gas bores 34 and 35 and a gas channel 36. A tubular member 37 defines a channel 38 for plastic and provides a conical valve seat for a spherical or part spherical valve member 39. Gas supplied to the gas bore 35 provides control for the valve member 39. Gas supplied to the gas bore 34 provides control for the gas assisted injection moulding process itself. The gas for both bores may be supplied from the same or from separate supplies. A needle valve member 40 associated compression spring 41 and adjustment screw 42 are disposed in the gas bore 34 to control gas flow therethrough. The force of the spring 41 on the needle valve member 40 may be adjusted by the screw plug 42. Plastic flow ports 43 lead through the nozzle body 30. Gas channel 36 leads to a further gas channel 44 which in turn leads to an externally screwthreaded internal gas nozzle 45 screwed into a complementary internally screwthreaded bore in the body 30. A nozzle tip 46 which is externally screwthreaded is screwed into a complementary internally screwthreaded part of the nozzle body 30.

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In operation, plastic for a product to be moulded from the moulding machine screw and cylinder and high pressure gas (normally nitrogen) for pressurising this plastic flows through the nozzle to the mould as already described in general with reference to figure 1.

5 The opening and closing of the plastic channel 38 is achieved by the movement of the spherically shaped ball or part of a ball 39 and its mating and seating with a conical valve seat on member 37. When the spherical ball is forced against the seat, the plastic channel 38 is closed. When forced forward by pressure exerted on the plastic from the moulding machine an
10 aperture 50 is opened for the plastic flow from the screw and cylinder towards the nozzle and into the mould. This operational position is shown in figure 4.

 Control of the ball movement is affected by a combination of the spring 33 and gas pressure on the internal piston 32. The movement or
15 travel of the ball is restricted in its backward movement by the nozzle body 30 and, in its forward position, by seating on the conical valve seat of member 37.

 The spring 33 is selected so that the ball is normally in a closed position but when pressure is exerted on the plastic for the transfer of
20 plastic into the mould, the ball will move axially against the spring pressure, thereby opening aperture 50.

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When it is required to close the aperture 50 and to resist the pressure in the plastic from the screw and cylinder and from the pressure exerted by the injection of the process control gas, gas pressure is applied to the piston 32 to add a force to that exerted by the spring 33, thereby exceeding the force exerted by the plastic and closing the ball 39 against the conical valve seat. This closed position of the ball is shown in figure 5.

The piston 32 is hollow with one end open. The walls of the piston 32 are about 0.5mm thick. The piston 32 is disposed so that gas supplied to gas port 35 flows into its open end. When gas is so supplied, it causes the piston 32 to expand radially, improving the seal between the piston 32 and the piston chamber 31, preventing the ingress of plastic and escape of gas whilst the aperture 50 is closed by the ball 39.

The gas for the control of the nozzle flows through the bore 34 and channel 36. Pressure exerted by this gas flow opens the needle 40 against the force of compression spring 41. The compressive force of this spring 41 can be adjusted by the setting of the screw plug 42.

When the gas control pressure is exerted, it first depresses the needle valve member 40 thereby permitting entry to the channel 44 so that the process control gas will then flow through the channel 44 and internal gas nozzle 45 into the molten plastic in the nozzle and then through the machine nozzle tip 46 and into the mould.

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At a later stage in the moulding cycle the gas control pressure is reduced and the member 40 will return to its closed position, thereby preventing the ingress of plastic from the mould down the channel 44 into the gas bore 34.

5 Gas in the mould may then be exhausted to atmosphere by the withdrawal of the nozzle tip from the seating in the mould 60. This movement is often referred to as 'sprue break' and has the effect of opening the gas flow circuit, thereby enabling the exhaust. This operational state is shown in figure 6.

10 In a modification of the above described embodiment means are provided for closing the hole at the position in the moulding where the gas is injected, as described above. After sprue break, the nozzle is returned to its forward position so that the nozzle is reseated against the mould, to enable a second injection of a small shot or slug of plastic 70 from the
15 nozzle by one of the three following alternative methods:

 In a first method shown in figure 7, plastic from the screw and cylinder is supplied allowing the ball 39 to open by relieving the gas pressure in the process control gas circuit, and at the same time rotating the screw so that a small amount of plastic 70 is forced
20 along the hollow gas channel in the nozzle tip and sprue or runner, and into the position of the hole. Alternatively, a small slug of plastic

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may be injected by the limited forward movement of the screw.

In a second method shown in figure 8, the plastic nozzle consists of a rotatable go/no go cam. Plastic material is displaced from within the nozzle tip 46 in a forward direction through the nozzle tip and sprue or runner when the space 71 within the material in the nozzle tip is reduced. Concurrent with this movement the ball 39 is in its closed position, preventing any of the displaced plastic being forced back into the machine cylinder.

In a third method shown in figure 9, an additional cylindrical hole 80 is provided in the nozzle body which is filled with plastic during each plastic injection stage. This plastic is displaced by the forward movement of a piston 81 under gas pressure from a third gas circuit 82 with pressure times to operate after the exhaust of the gas from the mould and when the nozzle tip is returned to its forward position.

In each of the above methods a controlled slug or shot of plastic is injected into the position of the hole without further filling of the gas channel within the moulding. Thereby the hole in the plastic is filled.

Possible moulding cycle sequences are illustrated in figures 10 and 11. Figure 10 shows a sequence in which the process control gas circuit supplying gas through port 35 and the plastic shut-off valve operation gas circuit supplying gas through port 34 are separate and operated with

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different pressure time programs. In both figures 10 and 11, time (T) is plotted as abscissa and gas pressure (P) as ordinate. In figure 10, the moulding cycle comprises a first stage from time A to B in which the plastic valve is open (that is valve member 39 displaced from its valve seat) and plastic injected through the nozzle into the mould. Thereafter gas pressure P1 is supplied through port 34 to shut off the plastic valve which remains until time C. At time D gas pressure is supplied through port 35 to pressurise the plastic in the mould itself. The pressure rises initially to value P2 and subsequently to value P3 before falling back to zero at time E when gas is exhausted from the mould by sprue break. Between time E and F the machine carriage is retracted and between time F and G returned to enable the small plastic plug to fill the gas entry hole in the moulding to be supplied. Between time H and I, the screw refills the cylinder for resupplying the mould through the nozzle in the heat moulding cycle and between time C and J the mould opens and closes to enable removal of the moulded product. During the refilling stage, the plastic shut-off valve is closed under pressure through port 35.

In figure 11, in contrast with the arrangement of figure 10 both gas flows are common and the pressure and timing are identical. This method is both more economic in control equipment and the usage of gas, and simplifies the setting up of the apparatus and moulding program conditions.

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Referring to figure 11, therefore, the moulding cycle comprises a first stage from time A to B as before in which the plastic valve is open with the valve member 39 displaced from its valve seat and plastic injected through the nozzle into the mould. Thereafter, the linked common gas circuit is pressurised by the gas assisted moulding control program. The plastic valve is shut by gas pressure with the gas valve in the common gas circuit open at time D to pressurise the plastic in the moulding. At time E gas is exhausted from the mould by sprue break and from both plastics and gas shut off valves pressure in plastic is relieved. Thereafter at time C, the machine carriage is retracted and the screw is refilled with plastic with the plastic shut off valve closed. The mould is opened to remove the moulding and the mould then closed following which the cycle repeats.

In a third variation it is possible to separately control the gas needle/piston from a separately controlled gas circuit to enable the gas shut off timing and gas pressure to be independent of the process control timing and pressure and the plastic shut-off timing and pressure.

Another form of nozzle is shown in figure 12. Referring to this figure, in some respects the nozzle is similar to those shown in figures 3 to 9. The nozzle comprises a nozzle body 90 which defines a piston chamber 91 in which a piston 92 loaded by a spring 93 is disposed. The nozzle 90 body also defines gas bores 94 and 95 and a gas channel 96. A tubular member

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97 defines a channel 98 for plastic and provides a conical valve seat for a spherical or part spherical valve member 99. Gas supplied to gas bore 94 provides control for valve member 99. Gas supplied to gas bore 95 provides control for the gas assisted injection moulding process itself. Gas bore 95 leads into a gas channel 100 which in turn leads to an externally threaded gas nozzle 101 screwed into a complementary internally threaded bore in the body 90.

Where this embodiment differs over the others described in that the gas nozzle 101 defines a conical valve seat 102 for a spherical or part spherical valve member 103 which is urged towards the valve seat by a spring 104. The spring 104 is retained in the nozzle 101 by means of a grub screw 105. The grub screw 105 allows for adjustment of the compression of the spring and is drilled to allow the passage of gas. Together, the valve seat 102, valve member 103 and spring 104 define a normally closed check valve assembly which controls the flow of gas through the nozzle 101 and gas channel 100.

In use, when gas pressure is applied to port 95 this acts on the valve member 103 causing the spring 104 to compress allowing the valve member 103 to move away from the valve seat 104, permitting gas to flow through the nozzle 101, into molten plastic in the nozzle and through nozzle tip 107 into a mould. When no gas pressure is applied the valve member

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103 will remain in contact with the valve seat 102 under the influence of the spring 104, preventing the ingress of plastic into the gas channel 100. Any pressure applied to the nozzle tip 107 side of the valve assembly will tend to urge the valve member 103 towards the valve seat 102.

5 The above described nozzles enable both gas injection and plastic shut-off to be controlled within the same unit. The use of gas pressure to activate plastic shut-off avoids problems which may be encountered with hydraulic control at the elevated temperatures of the plastic melt. High pressure gas is already available which avoids the need for additional power
10 packs and/or cylinders and pistons. The nozzle requires no external moving parts including pistons, cylinders, link rods and external springs thus giving economy in space. The nozzle resists plastic pressure in opposing flow directions at different time stages in the gas assisted moulding cycle. The apparatus and method of shutting off the plastic as described can be used
15 for conventional injection moulding, i.e. without the inclusion of gas assisted moulding. A separate source of high pressure gas can be used for the operation of the plastic shut-off valve.

 It will be appreciated that the above embodiments have been described by way of example only and that many variations are possible
20 without departing from the scope of the invention.

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CLAIMS

1. A nozzle valve having a body defining a passage for plastic, means for closing off the passage, means for activating the means for closing off under the control of gas pressure, a gas injection port for the supply of gas under pressure to plastic supplied through the passage and means for isolating the gas injection port from the passage.
2. A nozzle valve as claimed in claim 1 wherein the means for closing off the passage comprises a valve.
3. A nozzle valve as claimed in claim 2 wherein the valve comprises a ball valve having a spherical or part spherical valve member urged onto a conical valve seat to close the valve.
4. A nozzle valve as claimed in claim 3 wherein the valve member is urged onto the valve seat by resilient means.
5. A nozzle valve as claimed in claim 4 wherein the resilient means comprises a spring.
6. A nozzle valve as claimed in claim 3 wherein the means for activating the means for closing off the passage comprises a piston operable to urge the spherical or part spherical valve member onto the valve seat.
7. A nozzle valve as claimed in either claim 4 or 5 wherein the means for activating the means for closing off the passage comprises a

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piston operable to urge the spherical or part spherical valve member onto the valve seat to add a force to that exerted by the resilient means.

- 5 8. A nozzle valve as claimed in claim 6 or 7 wherein the means for activating the means for closing the passage additionally comprises a gas port through which gas under pressure may be supplied to operate the piston.
- 10 9. A nozzle valve as claimed in any of claims 6 to 8 wherein the piston is hollow with one end open and disposed in the nozzle so that gas supplied to operate the piston flows into its open end and wherein the piston is arranged so that in use when gas pressure is applied this causes the piston to expand radially, improving the seal between piston and nozzle.
- 15 10. A nozzle valve as claimed in any of claims 2 to 9 wherein the valve may be opened in operation by means of plastic under pressure supplied by a screw and cylinder arrangement.
- 20 11. A nozzle valve as claimed in claim 3 and any of claims 4 to 10 when appendant, directly or indirectly to claim 3, wherein the passage is defined by a tubular member which also provides the conical valve seat.
12. A nozzle valve as claimed in any of claims 2 to 11 wherein the valve

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is disposed upstream, in relation to the intended direction of plastic flow through the passage, to the point at which gas supplied through the gas injection port enters the passage.

5 13. A nozzle valve as claimed in any preceding claim additionally comprising means for activating the means for isolating under the control of gas pressure.

14. A nozzle valve as claimed in any preceding claim wherein the means for isolating the gas injection port from the passage comprises a valve.

10 15. A nozzle valve as claimed in claim 14 wherein the valve providing the means for isolating the gas injection port from the passage comprises a resiliently loaded valve member disposed to be urged from a closed position to an open position in which gas may be supplied through the port to plastic supplied through the passage to the mould, by the
15 means for activating the means for isolating under gas pressure.

16. A nozzle valve as claimed in claim 15 wherein the valve member comprises a piston.

17. A nozzle valve as claimed in either of claims 15 or 16 wherein the resilient loading is provided by a compression spring.

20 18. A nozzle valve as claimed in any of claims 15 to 17 wherein the means for activating comprises a second gas port through which gas

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under pressure may be supplied to urge the valve member to the open position against the resilient loading.

- 5 19. A nozzle valve as claimed in any preceding claim wherein means are provided enabling the nozzle to deliver a plug of plastic material at the end of a moulding cycle to close off the opening left by injected gas.
- 10 20. A nozzle valve as claimed in claim 19 wherein the means for enabling the nozzle to deliver a plug of plastic material comprise means for opening the means for closing the plastic passage again at the end of the cycle to deliver the plug.
21. A nozzle valve as claimed in claim 19 wherein the means for enabling the nozzle to deliver a plug of plastic material comprise an arrangement for displacing plastic already in the nozzle.
- 15 22. A nozzle valve as claimed in claim 19 wherein the means for enabling the nozzle to deliver a plug of plastic material comprise an additional piston and cylinder device for delivering a plug of material under pressure.
- 20 23. A nozzle valve as claimed in any preceding claim wherein the same supply of gas is used for the means for activating the means for closing off the passage and for pressurising plastic in the mould.
24. A nozzle valve as claimed in any of claims 1 to 22 wherein separate

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supplies of gas are used for the means for activating the means for closing off the passage and for pressurizing plastic in the mould.

25. Moulding apparatus comprising a nozzle valve as claimed in any preceding claim.

5 26. A method of gas assisted injection moulding including the steps of supplying plastic material to a mould, applying gas pressure to assist in shutting off the supply of plastic material and to permit the pressurisation by gas of plastic supplied to the mould and pressuring the plastic by gas pressure in the mould.

10 27. A method as claimed in claim 26 including the additional step of supplying a plug of plastic material at the end of the moulding cycle to close off an opening left by injected gas.

15 28. A method as claimed in either of claims 26 or 27 wherein the same supply of gas is used to assist in shutting off the supply of plastic material and to pressurize the plastic by gas pressure in the mould.

29. A method as claimed in any of claims 26 to 28 wherein separate supplies of gas are used to assist in shutting off the supply of plastic material and to pressurize the plastic by gas pressure in the mould.

20 30. A method as claimed in any of claims 26 to 29 involving using apparatus as claimed in any of claims 1 to 25.

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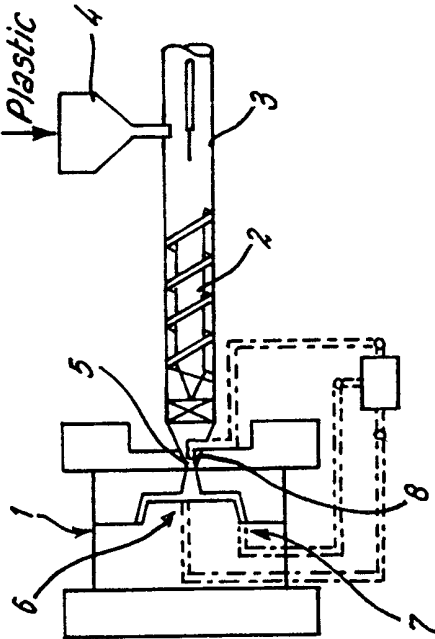


Fig. 1

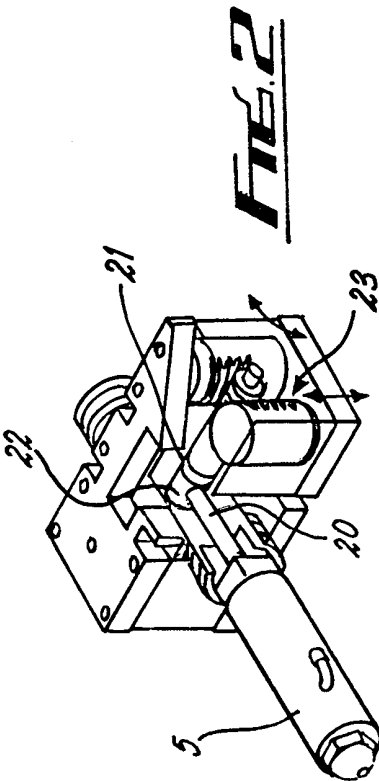


Fig. 2

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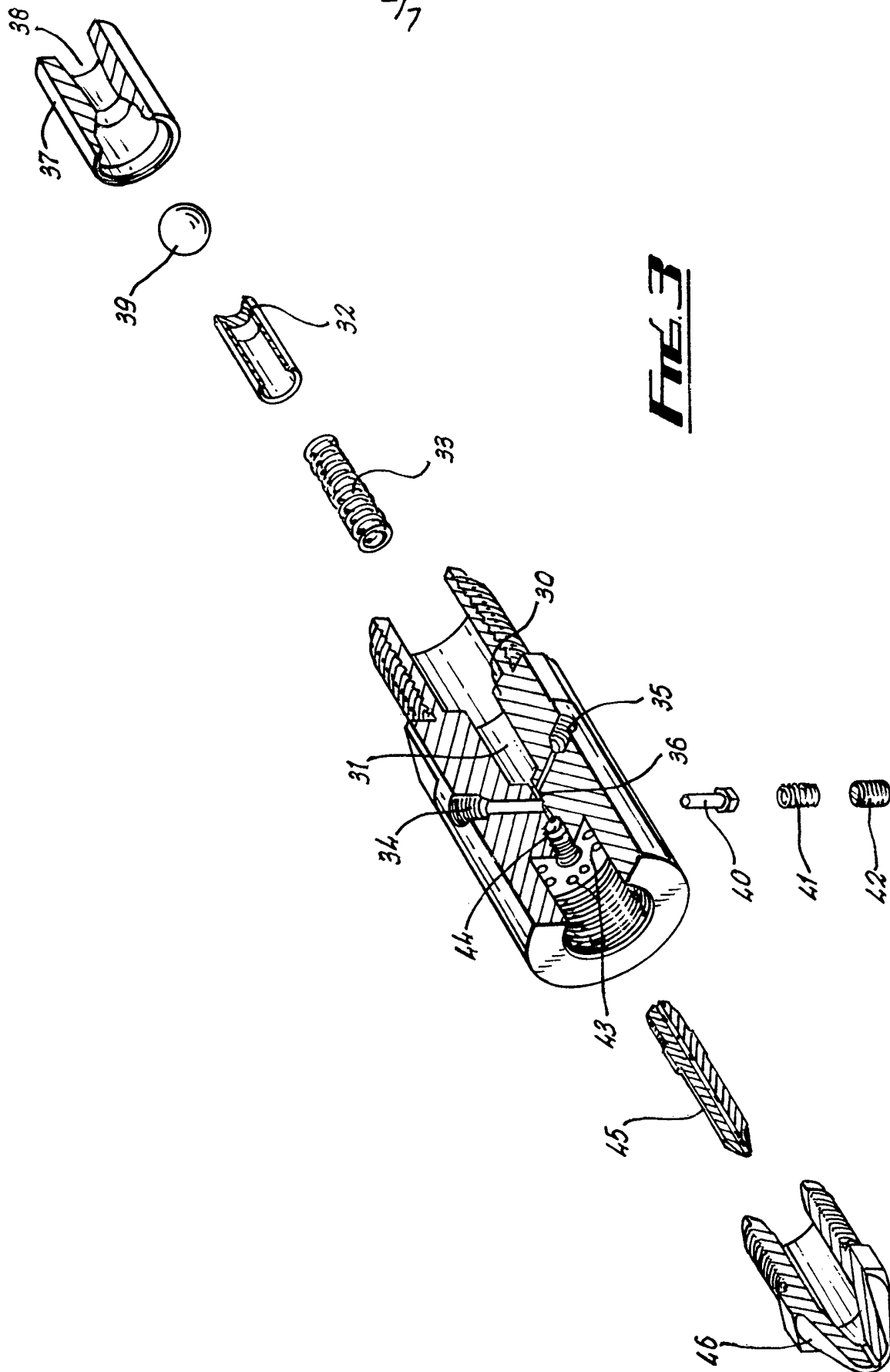


Fig. 3

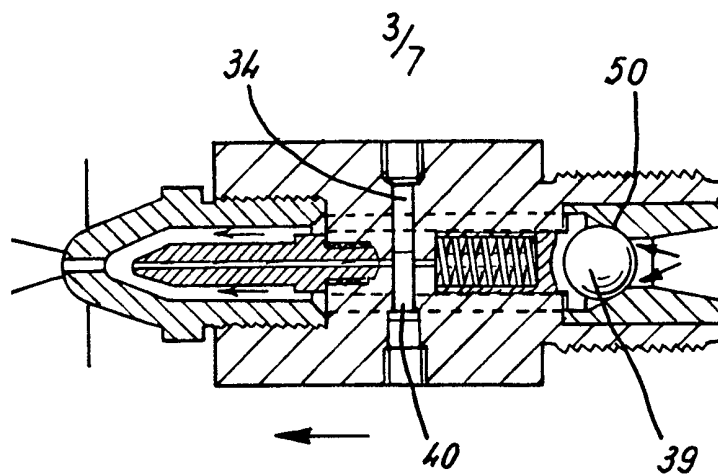


FIG. 4

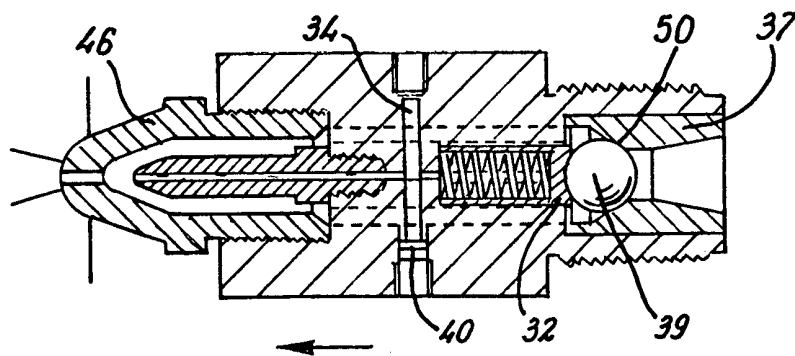


FIG. 5

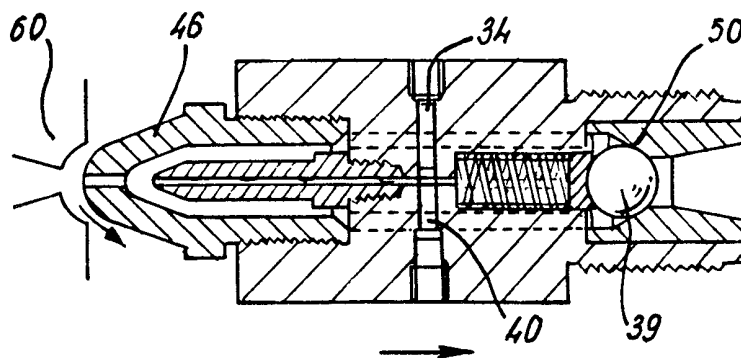
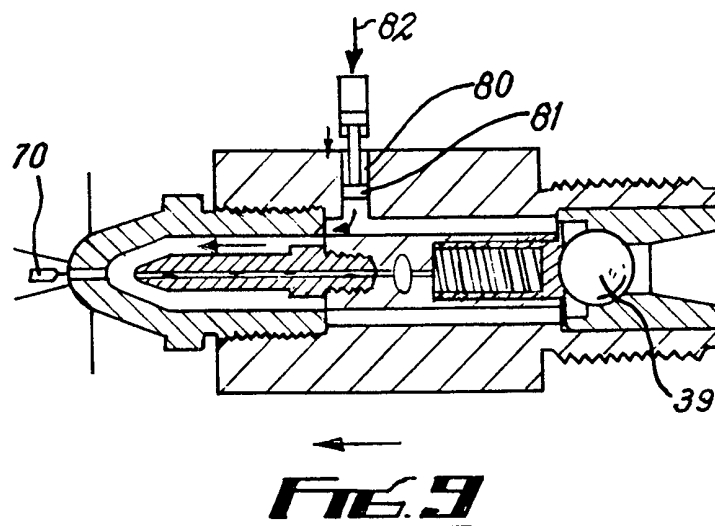
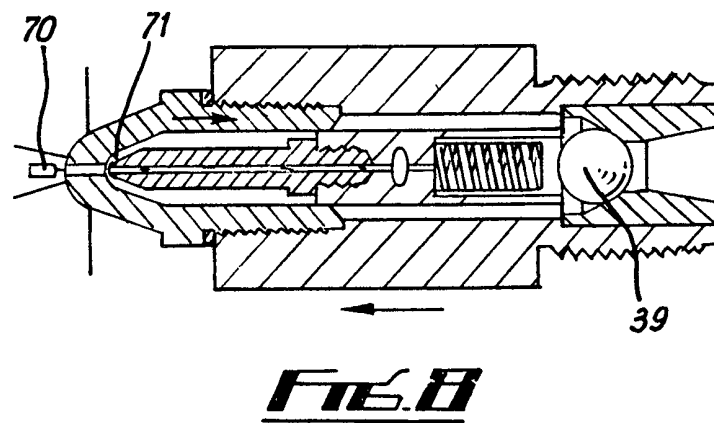
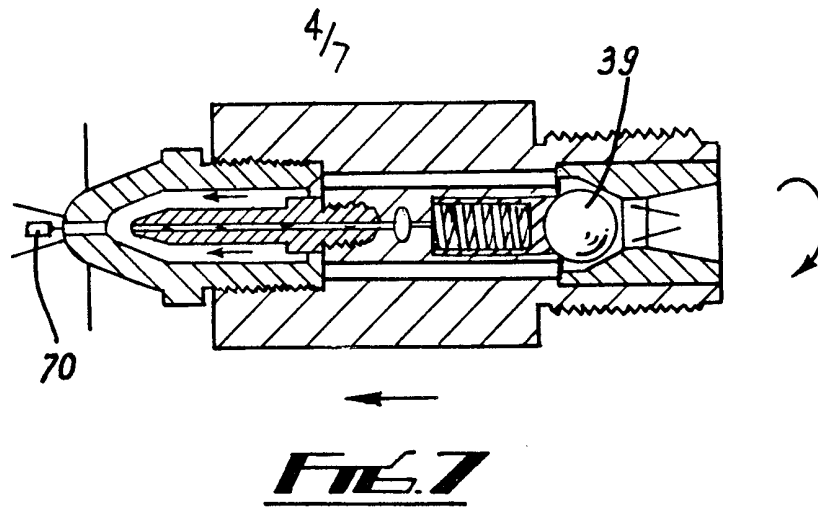
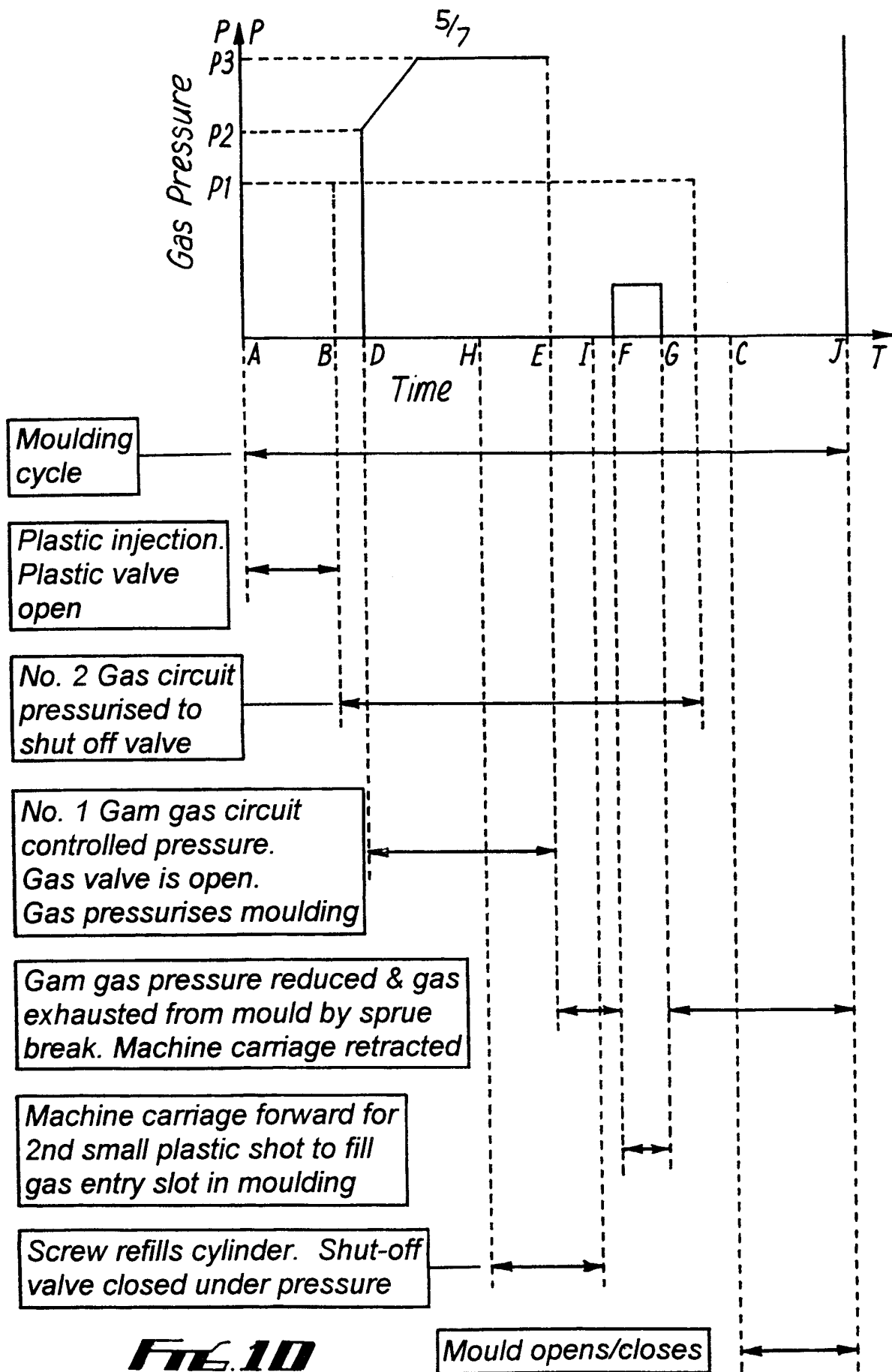
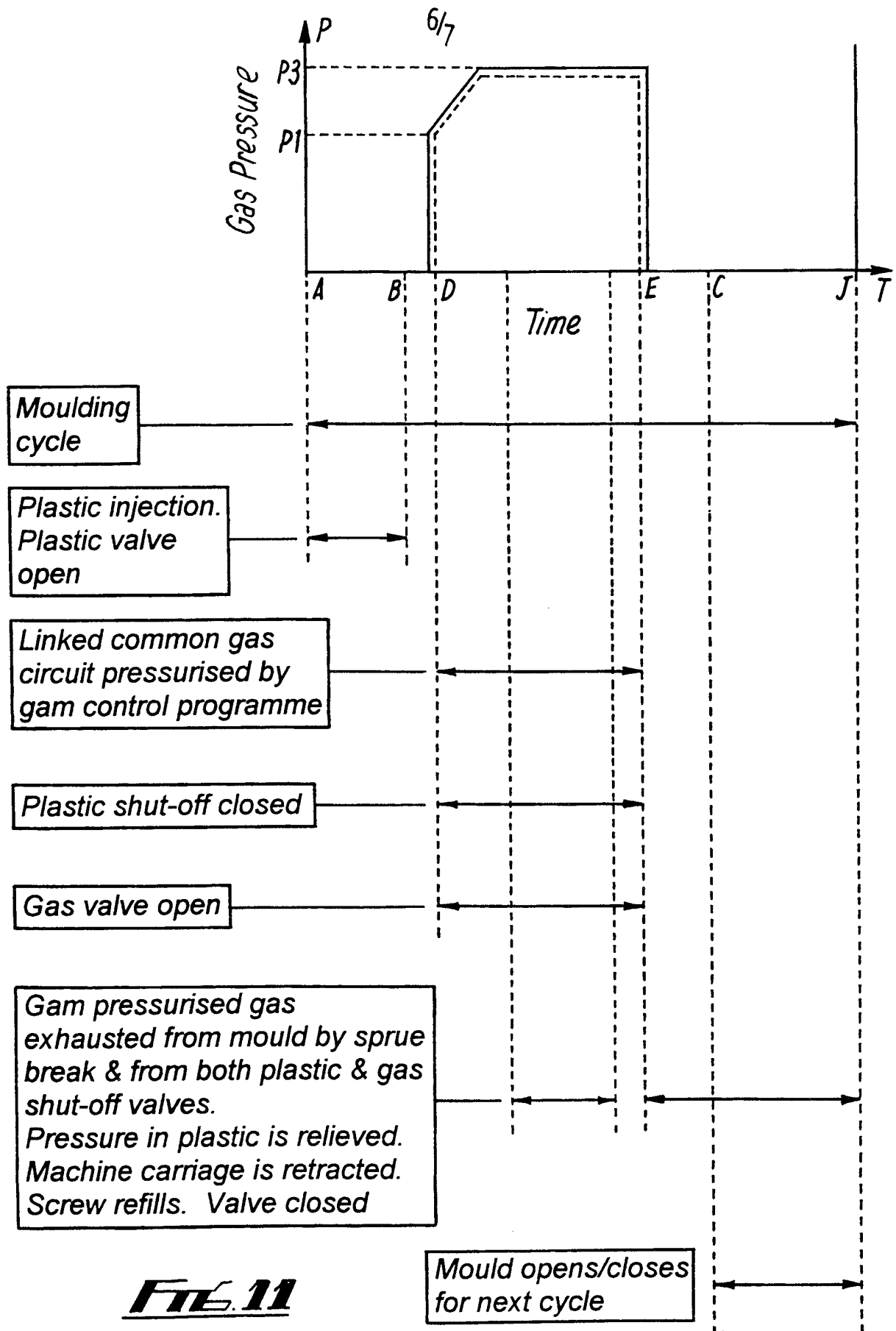


FIG. 6







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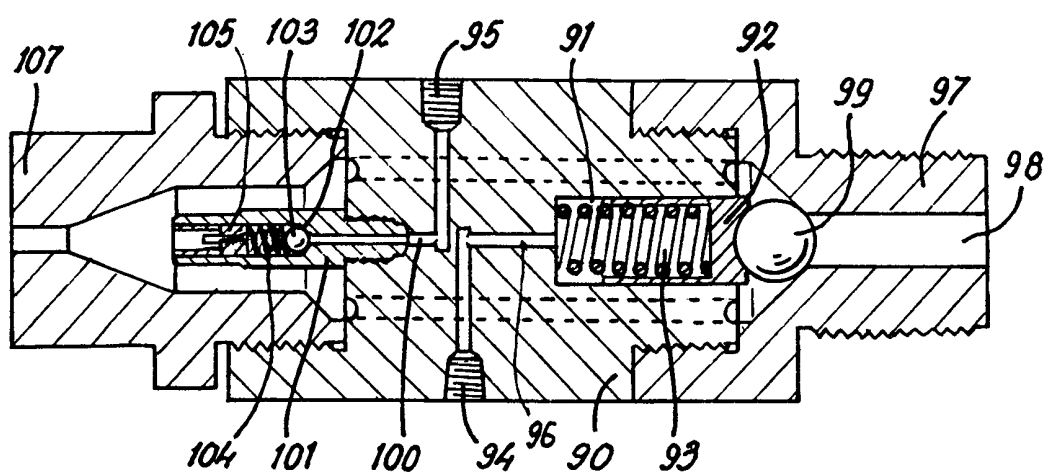


FIG. 12

INTERNATIONAL SEARCH REPORT

International Application No

PC/GB 99/02290

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B29C45/17 B29C45/23

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B29C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 321 160 A (LADNEY MICHAEL) 21 June 1989 (1989-06-21)	1,2,10, 13-15, 17,18, 23,25, 26,28,30 19-21,27
Y	column 6, line 32 -column 8, line 52; figure 3	
X	PATENT ABSTRACTS OF JAPAN vol. 17, no. 397 (M-1452), 26 July 1993 (1993-07-26) -& JP 05 077282 A (MEIKI CO LTD), 30 March 1993 (1993-03-30) abstract	1-3, 10-14, 23,25, 26,28,30

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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

15 November 1999

Date of mailing of the international search report

24/11/1999

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Bollen, J

INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 99/02290

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 1995, no. 05, 30 June 1995 (1995-06-30) -& JP 07 032419 A (AKIO YASUIKE), 3 February 1995 (1995-02-03) abstract ----	1,2,10, 12-14, 23,25, 26,28,30
Y	PATENT ABSTRACTS OF JAPAN vol. 17, no. 201 (M-1399), 20 April 1993 (1993-04-20) -& JP 04 345816 A (JAPAN STEEL WORKS LTD:THE), 1 December 1992 (1992-12-01) abstract ----	19-21,27
Y	DE 44 04 672 A (M + C SCHIFFER GMBH) 17 August 1995 (1995-08-17) column 4, paragraph 2; figures ----	19-21,27
A	DE 39 36 290 A (BATTENFELD GMBH) 28 February 1991 (1991-02-28) the whole document ----	1-3,10, 12-14, 25,26
A	PATENT ABSTRACTS OF JAPAN vol. 1996, no. 11, 29 November 1996 (1996-11-29) -& JP 08 187750 A (SEKISUI CHEM CO LTD), 23 July 1996 (1996-07-23) abstract -----	1-3,10, 12-15, 17,25,26

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 99/02290

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0321160 A	21-06-1989	US 4942006 A AT 89214 T CA 1306088 A DE 3880993 A JP 1215522 A JP 2619708 B MX 170699 B	17-07-1990 15-05-1993 11-08-1992 17-06-1993 29-08-1989 11-06-1997 08-09-1993
JP 05077282 A	30-03-1993	JP 2820813 B	05-11-1998
JP 07032419 A	03-02-1995	NONE	
JP 04345816 A	01-12-1992	NONE	
DE 4404672 A	17-08-1995	EP 0668140 A	23-08-1995
DE 3936290 A	28-02-1991	AT 401906 B AT 120991 A AT 402485 B AT 170990 A IT 1243794 B JP 2527837 B JP 3087223 A US 5106283 A	27-12-1996 15-05-1996 26-05-1997 15-10-1996 28-06-1994 28-08-1996 12-04-1991 21-04-1992
JP 08187750 A	23-07-1996	NONE	